ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 3, March 2013

Significance of Moisture Management for High Performance Textile Fabrics

Dr. S. K. Chinta, Ms. Pooja D. Gujar

D.K.T.E Textile & Engineering Institute, Ichalkaranji, India

Abstract: Moisture management is one of the key performance criteria in today's apparel industry, which decides the comfort level of that fabric. Apparel manufacturers have shifted their attention to the high-performance end of the moisture management fabric market and consumers place increasing importance on the performance of garments. This paper describes the need of moisture management in textile apparel, aims of development of moisture management fabrics, technical approach towards moisture management, desired attributes of moisture management fabric, route of moisture management, factors influencing wetting and wicking, various concepts of moisture managing textiles, developments in moisture management techniques and functional fields of application of moisture management technique.

Keywords: Moisture management, Comfort, Wetting, Wicking, Moisture Vapour Transmission

I. INTRODUCTION

Moisture management can be defined as the controlled movement of water vapour and liquid water (perspiration) from the surface of the skin to the atmosphere through the fabric. This action prevents perspiration remaining next to the skin. Moisture management is one of the key performance criteria in today's apparel industry, which decides the comfort level of that fabric. To be comfortable and to maintain the state of comfort, clothing must be designed to allow the body's heat balance to be maintained under a wide range of environmental conditions and body activity. It should fulfill this function without inhibiting the evaporation of humidity caused by perspiration and thus not interfering with the temperature regulation of the body. All these desired phenomena come under one technical term, called "moisture management". "Breathability" refers to the ease with which gases including water vapor can pass through the fabric. Liquid water released by the body is known as sensible perspiration. To be removed from the body it must be wicked through the fabric structure and then evaporate from the outside of the fabric. When gets evaporated heat is removed which helps to control the temperature of the body. Water vapor or insensible perspiration can pass through openings between fibers and yarns in a breathable fabric. When water vapor is produced by the body, heat is removed giving a direct cooling effect.

II. NEED FOR MOISTURE MANAGEMENT

Comfort can be defined as a pleasant physical, physiological and psychological equilibrium state between the human being and the environment. For a person engaged in normal routine indoor activity, energy expended is 50 watts/square meter/hour. The metabolic heat generated is readily dissipated through the clothing as sweat. At rest, a body will give off, about 60 ml of water vapour per hour at ambient conditions.

Moderate exertion (Walking) will increase the amount to about 450 ml per hour. During sporting activity, e.g., tennis or cycling, the metabolic heat increases six times and perspires 14 times (840 ml). During sweating, human body humidity is more or less absorbed by the textile apparels. If the humidity remains in the fabric and is not transported to the surface for evaporation, cooling cannot occur. The body warms up and even more sweat is produced.

During hard physical activity body sweats and in conventional clothing like cotton, the moisture traps out. The sports and leisure wear exert a barrier for efficient transfer of excess heat resulting in a rise in core body temperature and skin temperature greater than 37°C which increases sweating. The moisture locks out between clothing and body and then it increases body temperature and perspiration even more. The excess heat moistens the fabric, which then reduces the body heat and makes the wearer become so tired.

So the fabric worn next to the skin should have two important properties. The initial and the foremost property is to evaporate the perspiration from the skin surface and the second property is to transfer the moisture in the atmosphere and make the wearer feel comfortable. According to the researchers, what was needed therefore were textiles which feel soft and supple and do not cause any irritation on the skin such as scratching or itching. Even when the skin is wet with sweat, the clothing should not stick to the skin. The textiles commonly worn, act as a barrier between the external environment and the human body. The behaviour of moisture in various fibres is different owing to their physical and chemical properties making it uncomfortable to the wearer - unless the moisture is carried away by a natural drying process or aided by the apparel. Excessive moisture can add weight to the garment and even it irritates the skin of the wearer and increases the chances of the skin diseases. The moisture near to the skin makes skin cold when the wind blows in the cold days. Thus moisture management fabric is very useful if worn next to the skin at the time of exercising to keep the skin dry and make the wearer feel comfortable.

For sportsmen and women being able to concentrate fully on their sporting activity, it is essential that their clothing is comfortable to wear. Feeling nice and dry and comfortable in every situation is the best way of giving their individual performance an extra boost.

III. AIMS OF DEVELOPMENT OF MOISTURE MANAGEMENT FABRICS

- To transport the humidity to the atmosphere as fast as possible- The humidity has to reach the surface of the clothing first in order to evaporate. This occurs by capillary force, also known as wicking. The capillary force increases as the gaps between the individual fibres become thinner. That means that the finer the fibres, the smaller the gaps are, and the better the humidity transport.
- To evaporate the humidity as early as possible-The evaporation of humidity absorbed does not depend on the type of fibre, but on the surface area of the textile used. The larger the surface, the finer the fibres and the more fibres there are at the surface – the faster the humidity evaporation.
- To make the skin feel dry- Clothes which have a humid feel about them are unpleasant to wear. However, there are differences between materials as to the level from which water content makes the textile feel humid. Whereas cotton can absorb a certain volume of water without feeling humid, polyester feels wet and clammy even with small amounts of humidity stored in it. Moreover, thick textiles absorb more humidity compared to thinner fabrics, and their surface does not significantly expand in the process. That‘s why drying thick fabrics take considerably longer.

IV.TECHNICAL APPROACH TOWARDS MOISTURE MANAGEMENT

100 % cellulose fiber garments are widely used for general sports clothing and street wear, but the only fabrics actively promoted for high performance sportswear are made from synthetic fibers. Consumers and sportswear manufacturers have the view that cellulosic fibers are unsuitable for use in sportswear for high activity where sweat production needs to be dealt with. The reasons for this view of cellulosic fabrics are real and need to be addressed if the use of cellulosic fabrics in sportswear is to be increased. Cellulosic fabrics absorb water into the fiber structure and become heavy. This leads to stretching of the fabric, sticking to the skin and when activity ceases the fabric may feel cold against the skin. Higher levels of moisture absorbed in the fabric mean longer drying times. However, cellulosic fabrics are generally perceived to be more comfortable than synthetic fabrics when worn for normal day-to-day activities. They are preferred for a wide range of apparel fabrics where visual aesthetics, handle and comfort are important. In these areas synthetic fibers where the price and/or easy care performance are considered more important.

In order to deliver these positive properties of cellulosic fibers and to eliminate the negative aspects of performance, a new approach is needed. A successful cellulosic containing fabric will need to have a much lower absorption capacity than a 100 % cellulosic but must also deliver better visual aesthetics, handle and touch that cellulosic fibers are known for. The fabric would also have excellent moisture handling capability and be easy care. Moisture management can include the use of microfiber technology or the application of various softening finishes like silicones at the molecular level to enhance both hydrophobic and hydrophilic properties of a fabric. Hydrophilic fabrics or waterproof breathable fabrics are some advances in the field of moisture management in textiles. Water-resistant and moisture-permeable materials may be divided into three main categories - high-density fabrics, resin-coated materials and film-laminated materials which are selected by manufacturers according to finished garment requirements in casual, athletic, ski or outdoor apparel.

V. DESIRED ATTRIBUTES OF MOISTURE MANAGEMENT FABRIC

A good moisture management fabric must have following positive attributes-

- Optimum heat and moisture regulation
- Good air and water vapor permeability
- Rapid moisture absorption and conveyance capacity
- Absence of dampness
- Rapid drying to prevent catching cold
- Low water absorption of the layer of clothing just positioned to the skin
- Dimensionally stable even when wet
- Durable
- Breathability and comfort
- Easy care performance
- Lightweight

- Soft and pleasant touch
- Smart and functional design

VI. ROUTE OF MOISTURE MANAGEMENT

Human body act like perfect air conditioning. This sophisticated system reliably regulates our body temperature to a constant 37 °C, which is the optimum for maximum performance and comfort. An essential control mechanism of this system is the release of moisture at the right moment to protect the body from overheating. To maintain the body‘s optimum performance, a textile worn next to the skin has to support this regulative mechanism. A textile should work as our own skin. An important feature of any fabric is how it transports this water out of the body surface so as to make the wearer feel comfortable.

From the comfort point of view, moisture transmission through textile material both in liquid and vapour forms are equally important. Liquid moisture flow through textile materials is controlled by two processes-wetting and wicking. Wetting is the initial process, involved in fluid spreading; it is controlled by the surface energies of the involved solid and liquid. In case of textile material as soon as water wets the fibre, the water enters the inter fibre capillary channel and is dragged along by the action of capillary pressure.

Wetting, Wicking and Moisture Vapour Transmission properties are critical aspects for assessing the comfort performance of textile products. Wetting is the initial process involved in fluid spreading. The fibre-air interface is replaced with a fibre-liquid in this process. In the case of clothing with high wicking properties, moisture coming from the skin is spread throughout the fabric offering a dry feeling and the spreading of the liquid enables moisture to evaporate easily.

Water vapour and the liquid water are transmitted through the textiles by the following mechanism

1) Simple diffusion through inter yarn spaces: Diffusion is the main mechanism for transferring moisture in low moisture content conditions.This process is controlled by the water vapour pressure gradient across the inner and outer faces of the fabric. The resistance to diffusion is governed by the fabric construction, i.e., the size and concentration of inter yarn pores and the fabric thickness.
2) Capillary transfer through fibre bundles: Here the liquid water is "Wicked" through the yarns and desorbed or evaporated at the outer surface. The efficiency of yarn working depends on the surface tension, i.e., wettability of the fiber surfaces, and the size, volume and number of capillary spaces is determined by the choice of yarn and fabric construction.
3) Diffusion through individual fibres: This mechanism involves absorption of water vapour into the fibres at the inner surface of the fabric, diffusion through the fibre structure, and desorption at the outer surface. The ability of fibres to undergo water vapour diffusion depends on the hydrophilic or hydrophobic nature of the fibre.

VII. FACTORS INFLUENCING WETTING AND WICKING

It can now be easily concluded that wicking takes place only when there is a possibility of wetting. There are several factors, which can change the wetting and wicking properties of textiles. A few of them are listed below:

- Different fabrics experience different process conditions during their processing. If grey fabrics from same lot are divided into two portions and processed separately. Incidentally, one portion is scoured for less time as compared to the other. So, the less scoured lot will contain some hydrophobic matter, which will inhibit ready absorption of water and will show less wicking height in a specified time.
- Fabrics which contain yarn having more inter- fibre spaces (less twisted yarns) give wider diameter capillary. This will result into poor wicking action.
- If printed fabrics are not washed properly, they may contain some remaining print paste. Also, in some type of printing, printed fabrics are associated with binders, which are essentially hydrophobic in nature and hamper wetting and wicking of textiles.
- Fabrics treated with hydrophobic type of materials like conventional silicones will inhibit wicking by imparting hydrophobic behaviour. This can be overcome by treatment of fabric with a nano emulsion of a silicone (like; Resil Nanocelle G6). This gives good anchoring sites (with end amino groups) with fibres as well as large number of hydrophilic groups like, polyethers. This results into good wicking property as well as considerable hand feel. The nano behaviour of the product ensures extreme penetration and hence most effective performance.

VIII. VARIOUS CONCEPTS OF MOISTURE MANAGING TEXTILES

The term “moisture management” is often used as an advertising slogan. However, ideas differ among textile manufacturers as to how to achieve an optimized moisture management. In order to bring about the different effects, a suitable fibre material is used or a subsequent finishing is applied. It is also possible to combine specialized fibres and finishings.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 3, March 2013

- Hydrophobic textiles absorb only a very small amount of humidity. This can lead to insufficient transmission of humidity away from the skin and to an unpleasant damp feeling. Furthermore, the water which is not transported to the outer surface is no longer available for the cooling of the body.
- Hydrophilic textiles are known for their greater capacity to absorb humidity. Emerging liquid is absorbed efficiently and transported to the skin surface for evaporation. However, after exercise, a larger amount of liquid has to evaporate, which can cause stronger cooling and freezing.
- Combinations of inner hydrophobic and outer hydrophilic layers are designed to transport humidity rapidly from the skin and evaporate it on the outside. The special construction of the material enables transportation of humidity from the inside to the outside of the textile to take place. The two-sidedness of the fabric is either attained by processing different materials during manufacturing or by varying coatings of the fabric surfaces.
- Textiles which are in part hydrophobic are manufactured by the application - for example with a puncture technique - of a hydrophobic coating on the inner side of a hydrophilic fabric. The idea is that humidity can be transmitted through the hydrophilic "windows", while the hydrophobic areas do not absorb water and stay dry, leaving the skin with a dry feeling.
- Micro fibres, by virtue of their extreme fineness, form especially small gaps and have a big surface area. This leads to high capillary effect for the transportation of humidity, and rapid evaporation.
- Special fibres are designed to increase the capillary force and the humidity transportation, by means of special profiles (for example trilobal). The larger surface area of these fibres also serves to promote evaporation.

IX. DEVELOPMENTS IN MOISTURE MANAGEMENT TECHNIQUES

9.1 Waterproof Breathable Fabrics

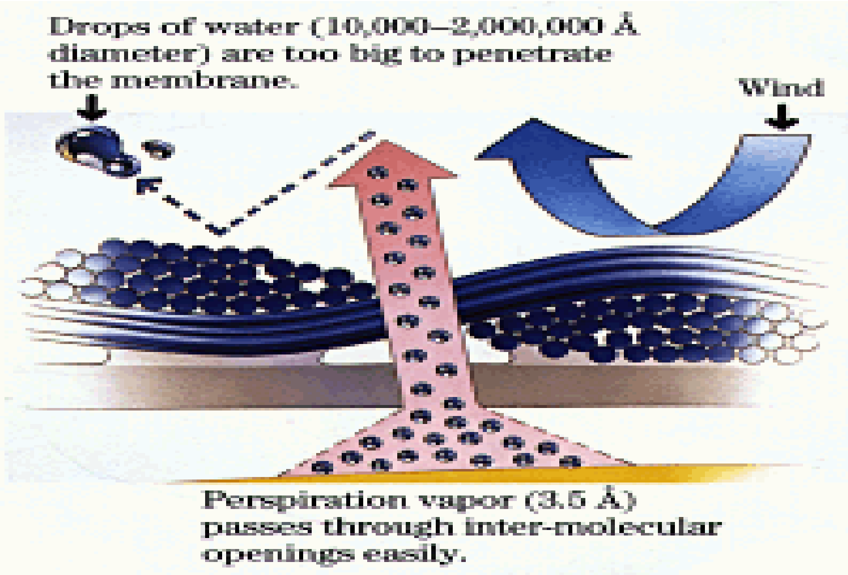

Figure 1:- Waterproof, Moisture Permeable Mechanism

These are designed for use in garments that provide protection from the environmental factors like wind, rain and loss of body heat. Waterproof fabric completely prevents the penetration and absorption of liquid water. The term breathable implies that the fabric is actively ventilated. Breathable fabrics passively allow water vapour to diffuse through them yet prevent the penetration of liquid water. High functional fabrics support active sportswear with importance placed on high functions as well as comfort.

9.2 Spacer Fabric

Spacer structures are fabric constructions comprising two separate fabric webs, which are joined together by spacer threads or fibres of varying rigidity. The intermediate zone creates a layer of air, which has an insulating and thermoregulatory effect. Modifying the structure of the knitted construction can alter the amount of air incorporated in the assembly.

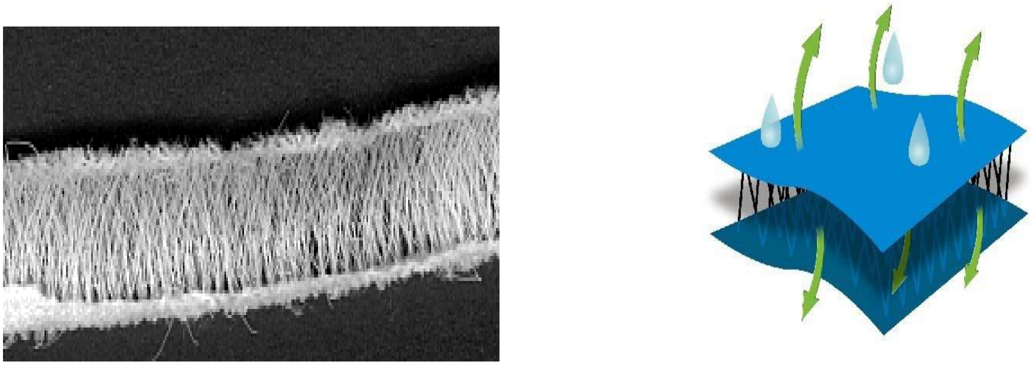

Figure 2:- Structure of spacer fabric

Spacer fabrics are 3D fabrics that comprise of two outer textile substrates that are joined together and kept apart by an insert of spacer yarns, mostly monofilaments. This creates a ventilated layer of air, allowing heat and moisture to escape. One reason for development of spacer fabrics was an attempt to replace toxic, laminated-layer foam with a single, synthetic fibre type fabric, thus facilitating future re-cycling. An important advantage is the low weight in proportion to the large volume. The application areas of spacer fabric are unlimited ranging from healthcare, safety, military, automotive, aviation and fashion. Currently it is being largely used for functional clothing comprising sports shoes, bra cups, shoulder pads, knee and elbow protectors etc.

9.3 Phase Changing Materials

Phase Change is the process of going from one state to another, e.g. from solid to liquid. Any material that experiences the process of phase change is named as Phase Change Materials (PCM). Phase Change Materials are waxes that have the distinctive capacity to soak and emit heat energy without altering the temperature. These waxes include Eicosane, Octadecane, Nonadecane, Heptadecane and Hexadecane. They all possess different freezing and melting points and when mixed in a microcapsule it will accumulate heat energy and release heat energy and maintain their temperature range of 30-34°C, which is very comfortable for the body.
PCM microcapsules can create small, transitory heating and cooling effects in garment layers when the temperature of the layers reaches the PCM transition temperature.. The temperature of the PCM garment layers must vary frequently for the buffering effect to continue the efficiency of work under high stress.

9.4 Pine Cone Effect

Pine cones on the trees are seemed to be closed but when they fallout from the tree it gets opened to release the seeds. The scales of the pine cone get open as they are made up of two layers of stiff fibers running in different directions. As the cone dries out, the scales inside gets expanded more than outside, causing the outer scales to bend outwards, releasing the seeds inside which is the principle used in the smart fabric.

Figure 3:- Pine Cone when Dry

Figure 4:- Pine Cone when Damp

The pine cone effect is a technology designed to offer a solution to the discomfort sensations caused by the moisture which is built up due to the changing temperature in clothing. It is impossible to predict the Indian temperature, humidity and activity level so that to accommodate in a selection of clothing to ensure comfort. There may be the other ways of producing ventilating or insulating fabrics by adding or removing layers of clothing, addition of garment parts or by introducing ventilating features to the garments but the limited availability of space and the wearer's ability makes discomfort sensations, to overcome this the pine cone effect is employed in clothing which is advantageous over others.

X.FUNCTIONAL FIELDS OF APPLICATION OF MOISTURE MANAGEMENT TECHNIQUE

- Inner wears
- Athletic wear (active sportswear)
- Performance wear (climbing, walking, skiing)
- Comfort wear (nightwear)
- Military (multi-climate clothing)
- Health (hospital bed linens, wound dressings)
- Agricultural technology (Geo-textiles, greenhouse screening panels, soil moisture control)
- Technical solutions (Formula 1 protective clothing, firefighting, industrial clothing)
- Industrial (filter & valve technology, building, packaging)
- Upholstery (transport)

XI. CONCLUSION

For comfort properties of textiles with varying end use applications, in the normal textile sector, technical textiles and other fields, moisture management play a key role. Because of proper moisture management, textiles can be made tailor-made for its specific end use. Apparel manufacturers are shifting their attention to the high-performance end use of the Moisture Management Fabrics. As manufacturers of sports and active outdoor wear strive to improve the functionality of their collections, the future will see further developments in the field of moisture management fabrics.

REFERENCES

1. Anson S., Moisture Management Fabrics Market Set to Grow to Meet Demand for Performance,http://www.fibre2fashion.com/industry-article/6/536/moisture management1.asp,
2. Gunaseelan, Moisture Management and Wicking, http://www.fibre2fashion.com/industry -article/22/2183/moisture-management-and-wicking1.asp.
3. Dr. Petry, Textile Auxiliaries, http://www.drpetry.de/pdf/MoistureManagement_e.pdf.
4. Dr. Gokarneshan N., Senthil Kumar B., Mythili S., A Comparative Study on the Moisture Transmission Characteristics on Grey and Finished Fabrics, http://www.fibre2fashion.com/industry-article/31/3061/ A-Comparative-Study on-the Moisture-Transmission-Characteristics-on-Grey-and-Finished-Fabrics 1.asp.
5. Dr .Ramchandran T. and Sampath M. B., Study of Moisture Management Finish on Woven Fabrics, ATNT 2007 on 18-20, June 2007 at KCT,Coimbatore-6.
6. Firgo H., Friedrich Suchomel, Tom Burrow, Tencel® High Performance Sportswear, Lenzinger Berichte, Vol. 85, pp 44-50, 2006.
7. Prasad A. K., Novel Effects in Garment Processing and Value Added Finishes, Journal of The Textile Association, Vol. 68, No.1, pp 39-42, May-June 2007.
8. Mrs. Agrawal Y., Mr. Jaiswal H., Mrs. Kapoor R., Moisture Management, http://www.fibre2fashion.com/industryarticle/42/4122/moisturemanagement1.asp.
9. Wallace M., 100% Moisture Management, Journal of Textile and Apparel, Technology And Management, Vol. 2, No.3, Summer 2002.